



10-15-04

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Serial Number: 04/13/2004  
Filing Date: 04/13/2004  
Applicant(s): Simkulet, et al.  
Title: An Integrated Panoramic and Forward View Endoscope  
Group Art Unit: Unknown  
Examiner: Unknown

### Information Disclosure Statement

Commissioner for Patents  
PO Box 1450  
Alexandria, VA 22313-1450

Sir:

Attached is a completed Form PTO/SB/08 and copies of the references cited thereon. Following are comments on these references pursuant to Rule 98:

#### U.S. Patent Documents

U.S. patent 6,793,356 B2 by Kiyoshi Kumata and Shinichi Tanaka appears to comprise an omnidirectional vision sensor comprising a single body of revolution mirror with a convex surface and symmetry about an axis of revolution. This patent appears to differ from the present invention at least by the means of collecting the omnidirectional image. The single reflector plus cutaway section produces a wide field of view with blind spots between the forward and panoramic fields of view, whereas the two reflector plus forward imaging elements of the present invention produce a seamless field of view with matched magnifications. In addition, the present invention is designed specifically to integrate with endoscope / borescope imaging systems.

U.S. patent 6,788,333 B1 by Matthew Uyttendaele and Richard Szeliski appears to comprise a means of capturing panoramic video by utilizing processing means to integrate multiple videos captured from a multi-camera rig. This patent appears to differ from the present invention at least by the means of acquiring the panoramic video. This patent uses a multi-camera rig to acquire video of a field of view of 360 degrees, whereas the present invention utilizes a unique optical system to acquire the 360 degree field of view on a single camera or image plane. The present invention requires no processing and is designed specifically to integrate with endoscope and borescope imaging systems.

U.S. patent 6,754,614 B1 by George Barton and Jeffrey Beckstead appears to comprise a single element linearized panoramic mirror and the means to achieve the desired field of view and distortion based on the optical design of the reflective surface. This patent appears to differ from the present invention at least in the geometry and number of elements used to obtain the panoramic field of view. This patent utilizes one reflector to obtain the panoramic field of view and does not include means for acquiring any of the field of view forward of the reflector. Whereas the present invention utilizes two reflectors to collect the panoramic field of view, includes forward optics to provide a continuous field of view greater than a hemisphere with matched brightness and magnifications, and is designed to specifically be integrated with a endoscope / borescope imaging system.

U.S. patent 6,621,516 B1 by Thomas Wasson, et al., appears to comprise a means of recording an image of the interior of a pipe utilizing a panoramic lens and a camera mounted on a self-contained cart. This patent differs from the present invention at least in the size application and performance. This patent is meant to inspect diameters from 6 to 30 inches, utilizes a single reflector to image only the panoramic or peripheral field of view, and is meant to be mounted on a self-contained cart for pipe inspection. Whereas, the present invention is designed to inspect channels significantly smaller than 6 inches in diameter, utilizes a two-reflector configuration to collect a field of view greater than a hemisphere, including panoramic and forward fields of view integrated on a single image plane, and is designed to be integrated in a endoscope / borescope imaging system.

U.S. patent 6,611,282 B1 by Sergey Trubko, et al., appears to comprise an super wide angle imaging apparatus. The Remote Reality invention is a super wide-angle panoramic imaging apparatus that claims up to a 260° vertical field of view using a two reflective and multiple refractive surfaces in a configuration. The invention includes an undefined blind spot (forward) along the optical axis. The invention claims a single view point while also having a substantially flat and stigmatic image plane. This invention differs from the present invention at least in the configuration of the optical surfaces. . This invention includes an undefined blind spot (forward) along the optical axis, whereas the present invention achieves a seamless field of view greater than 240 degrees with matched brightness and magnification and is designed to be integrated with endoscope / borescope imaging systems.

U.S. patent 6,449,103 B1 by Jeffrey Charles, appears to comprise a panoramic imaging system with a panoramic field of view, and efforts to maximize that field of view for near field applications. The Charles' patent includes a frontal exclusion zone of about 60 degrees that can be tapered approaching the far field by the use of a torroidal-shaped reflector. Although this exclusion zone eventually disappears as a point where the boundaries of the panoramic field meet, there is no account in the patent for the overlapping area past the point of convergence in the processing or interpretation of the image. The minor disclosure of including forward optics to image the frontal exclusion zone makes no mention of details of how to match the magnification or the relative F/# of the integrated images as well as a means of interpreting or processing the overlapping images. The mere inclusion of forward viewing lenses does not automatically lend itself to an easily interpretable image. The focus of the optical system is near field prior to the overlap. Although there is provision to include the forward viewing optics to image the frontal exclusion zone, there will only be one point (or one radial distance) in which the frontal zone and the panoramic zone exist with either no gap or no overlap. Conversely, the present invention provides a full omnidirectional image with a seamless presentation of forward and panoramic fields of view integrated on a single image plane. In addition, the Charles patent makes no provisions for integrating the system in an endoscope or borescope configuration.

U.S. patent 6,424,377 B1 by Edward Driscoll, Jr., et al., appears to comprise a means of obtaining panoramic images from a camera. This patent primarily differs from the present invention at least in the fact that there is no means for imaging forward of the optical system and there are no provisions to integrate it on a small scale for endoscopic or borescopic imaging. This patent also concentrates on the panoramic field of view and only makes provisions to extend the panoramic view as far forward as possible by changing the shape of the reflector. Whereas the present invention provides a continuous field of view greater than a hemisphere with matched brightness and magnification on a single image plane, and is designed to be integrated with endoscopic or borescopic imaging systems.

U.S. patent 6,392,687 B1 by Edward Driscoll, Jr., et al., appears to comprise a means of obtaining panoramic images from a camera. This patent primarily differs from the present invention at least in the fact that there is no means for imaging forward of the optical system and there are no provisions to integrate it on a small scale for endoscopic or borescopic imaging. This patent also concentrates on the panoramic field of view and only makes provisions to extend the panoramic view as far forward as possible by changing the shape of the reflector.

Whereas the present invention provides a continuous field of view greater than a hemisphere with matched brightness and magnification on a single image plane, and is designed to be integrated with endoscopic or borescopic imaging systems.

U.S. patent 6,388,820 B1 by Edward Wallerstein, et al., appears to comprise a means of obtaining panoramic images from a camera. This patent primarily differs from the present invention at least in the fact that there is no means for imaging forward of the optical system and there are no provisions to integrate it on a small scale for endoscopic or borescopic imaging. This patent also concentrates on the panoramic field of view and only makes provisions to extend the panoramic view as far forward as possible by changing the shape of the reflector. Whereas the present invention provides a continuous field of view greater than a hemisphere with matched brightness and magnification on a single image plane, and is designed to be integrated with endoscopic or borescopic imaging systems.

U.S. patent 6,373,642 B1 by Edward Wallerstein, et al., appears to comprise a means of obtaining panoramic images from a camera. This patent primarily differs from the present invention at least in the fact that there is no means for imaging forward of the optical system and there are no provisions to integrate it on a small scale for endoscopic or borescopic imaging. This patent also concentrates on the panoramic field of view and only makes provisions to extend the panoramic view as far forward as possible by changing the shape of the reflector. Whereas the present invention provides a continuous field of view greater than a hemisphere with matched brightness and magnification on a single image plane, and is designed to be integrated with endoscopic or borescopic imaging systems.

U.S. patent 6,369,818 B1 by Hoffman, et al., appears to comprise a means of obtaining panoramic images from a camera and then obtaining perspective correct data from that image data. This patent primarily differs from the present invention at least in the fact that there is no means for imaging forward of the optical system and there are no provisions to integrate it on a small scale for endoscopic or borescopic imaging. This patent also concentrates on the panoramic field of view and only makes provisions to extend the panoramic view as far forward as possible by changing the shape of the reflector. Whereas the present invention provides a continuous field of view greater than a hemisphere with matched brightness and magnification on a single image plane, and is designed to be integrated with endoscopic or borescopic imaging systems.

U.S. patent 6,356,397 B1 by Vishvjit Singh Nalwa, appears to comprise a panoramic viewing system, which utilizes multiple cameras to create a panoramic scene created by imaging different reflective surfaces of a polyhedron. This patent differs significantly from the present invention in that it uses multiple views from multiple cameras fused together to create a panoramic view, while the present invention utilizes a combination of reflective and refractive surfaces to create a field of view greater than a hemisphere on a single image plane with matched magnification, and brightness between the forward and panoramic fields of view.

U.S. patent 6,333,826 B1 by Jeffrey Charles, appears to comprise a panoramic imaging system with a panoramic field of view, and efforts to maximize that field of view for near field applications. The Charles' patent includes a frontal exclusion zone of about 60 degrees that can be tapered approaching the far field by the use of a torroidal-shaped reflector. Although this exclusion zone eventually disappears as a point where the boundaries of the panoramic field meet, there is no account in the patent for the overlapping area past the point of convergence in the processing or interpretation of the image. The minor disclosure of including forward optics to image the frontal exclusion zone makes no mention of details of how to match the magnification or the relative  $F/\#$  of the integrated images as well as a means of interpreting or processing the overlapping images. The mere inclusion of forward viewing lenses does not automatically lend itself to an easily interpretable image. The focus of the optical system is near field prior to the overlap. Although there is provision to include the forward viewing optics to image the frontal exclusion zone, there will only be one point (or one radial distance) in which the frontal zone and the panoramic zone exist with either no gap or no overlap. Conversely, the present invention provides a full omnidirectional image with a seamless presentation of forward and panoramic fields of view integrated on a single image plane. In addition, the Charles patent makes no provisions for integrating the system in an endoscope or borescope configuration.

U.S. patent 6,226,035 B1 by James Korein, et al., appears to comprise an adjustable imaging system with wide angle capability. This patent provides the means for collecting a very wide field of view or a narrow field of view with a single lens system. It is integrated with a pan tilt zoom camera system. This patent differs from the present invention at least in the type of imaging system it is integrated with and the size of the field of view. This invention claims a wide field of view and is meant to integrate with a pan tilt zoom camera system, whereas the

present invention is integrated with a borescope or endoscopic imaging system and achieves a significantly wider field of view that is greater than a hemisphere.

U.S. patent 6,222,683 B1 by Jan Hoogland, et al., appears to comprise a means of obtaining panoramic images from a camera. This patent primarily differs from the present invention at least in the fact that there is no means for imaging forward of the optical system and there are no provisions to integrate it on a small scale for endoscopic or borescopic imaging. This patent also concentrates on the panoramic field of view and only makes provisions to extend the panoramic view as far forward as possible by changing the shape of the reflector. Whereas the present invention provides a continuous field of view greater than a hemisphere with matched brightness and magnification on a single image plane, and is designed to be integrated with endoscopic or borescopic imaging systems.

U.S. patent 6,195,204 B1 by Vishvjit Singh Nalwa, appears to comprise a panoramic viewing system, which utilizes multiple cameras to create a panoramic scene created by imaging different reflective surfaces of a polyhedron. This patent differs significantly from the present invention in that it uses multiple views from multiple cameras fused together to create a panoramic view, while the present invention utilizes a combination of reflective and refractive surfaces to create a field of view greater than a hemisphere on a single image plane with matched magnification, and brightness between the forward and panoramic fields of view.

U.S. patent 6,130,783 by Yasushi Yagi, et al., appears to comprise a means of obtaining panoramic images from a camera. This patent primarily differs from the present invention at least in the fact that there is no means for imaging forward of the optical system and there are no provisions to integrate it on a small scale for endoscopic or borescopic imaging. This patent also concentrates on the panoramic field of view and only makes provisions to extend the panoramic view as far forward as possible by changing the shape of the reflector. Whereas the present invention provides a continuous field of view greater than a hemisphere with matched brightness and magnification on a single image plane, and is designed to be integrated with endoscopic or borescopic imaging systems.

U.S. patent 6,118,474 by Shree Nayar appears to comprise a means of obtaining omnidirectional images from a camera. This patent primarily differs from the present invention at least in the fact that there is no means for imaging forward of the optical system and there are

no provisions to integrate it on a small scale for endoscopic or borescopic imaging. This patent also concentrates on the panoramic field of view and only makes provisions to extend the panoramic view as far forward as possible by changing the shape of the reflector. Whereas the present invention provides a continuous field of view greater than a hemisphere with matched brightness and magnification on a single image plane, and is designed to be integrated with endoscopic or borescopic imaging systems.

U.S. patent 6,028,719 by Jeffrey Beckstead and Steven Nordhauser appears to comprise a means of imaging an integrated forward and panoramic field of view onto a single image plane. This patent appears to differ from the present invention at least by the means of collecting the panoramic field of view and by the boundaries between the panoramic and forward field of view. This patent collects the panoramic field of view via a single reflective element and thereby defines the forward boundary of the panoramic field of view to not coincide with the rear boundary of the forward field of view, thereby producing an imaging gap between the two fields of view. Whereas the present invention utilizes a two reflector geometry to collect the panoramic field of view and has defined that field of view such that it matches seamlessly with the forward field of view. In addition, the present invention has provisions in the optical design to also match the magnification and brightness ( $F/\#$ ) between the two fields of view.

U.S. patent 6,002,430 by Danny McCall and H. Lee Martin appears to comprise a method to obtain a spherical image, by combining through computer processing the images from two cameras, each with a field of view of 180 degrees. This patent differs from the present invention in that it utilizes an off-the-shelf camera lens to achieve the wide field of view that at its largest is only 180 degrees and concentrates on the processing and hardware required to produce the spherical image. The single element, 180 degree field of view lens disclosed is most likely a fish-eye lens, and there are no provisions to integrate this technology in endoscopic/borescopic imaging systems. Whereas the present invention is designed specifically to integrate in endoscopic/borescopic imaging systems and the field of view is at a minimum 240 degrees.

U.S. patent 5,760,826 by Shree Nayar appears to comprise a means of obtaining omnidirectional images from a camera. This patent primarily differs from the present invention at least in the fact that there is no means for imaging forward of the optical system and there are no provisions to integrate it on a small scale for endoscopic or borescopic imaging. This patent also concentrates on the panoramic field of view and only makes provisions to extend the

panoramic view as far forward as possible by changing the shape of the reflector. Whereas the present invention provides a continuous field of view greater than a hemisphere with matched brightness and magnification on a single image plane, and is designed to be integrated with endoscopic or borescopic imaging systems.

U.S. patent 5,359,363 by Daniel Kuban, et al., appears to comprise an omniviewing camera system for surveillance applications including a wide angle lens mounted on a pan and tilt head to achieve the omnidirectional imaging capabilities. This patent differs from the present invention at least in that it is not compatible with endoscopic / borescopic imaging systems based on the pan and tilt requirements and the omnidirectional imaging is achieved through the pan and tilt and not simultaneously on a single image plane. Whereas the present invention is designed specifically to integrate with endoscopic / borescopic imaging systems and achieves the greater than 240 degree image on a single image plane.

U.S. patent 5,185,667 by Steven Zimmermann appears to comprise an omniviewing camera system for surveillance applications including a wide angle lens mounted on a pan and tilt head to achieve the omnidirectional imaging capabilities. This patent differs from the present invention at least in that it is not compatible with endoscopic / borescopic imaging systems based on the pan and tilt requirements and the omnidirectional imaging is achieved through the pan and tilt and not simultaneously on a single image plane. Whereas the present invention is designed specifically to integrate with endoscopic / borescopic imaging systems and achieves the greater than 240 degree image on a single image plane.

#### Published Papers

The publication entitled "Omnidirectional Vision" by Shree Nayar describes details of omnidirectional imaging specifically related to the panoramic field of view and does not include means of incorporating the complete field of view forward of the imaging system. The focus of the paper also includes detailing single viewpoint imaging and perspective projection.





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Sheet 1 of 2

**Complete if Known**

Application Number	10/822,964
Filing Date	April 13, 2004
First Named Inventor	Simkulet
Art Unit	3739
Examiner Name	
Attorney Docket Number	

## U. S. PATENT DOCUMENTS

U. S. PATENT DOCUMENTS					
Examiner Initials*	Cite No. <sup>1</sup>	Document Number	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		Number-Kind Code <sup>2 (if known)</sup>			
		US- 6,793,356 B2	09-21-2004	Kumata & Tanaka	
		US- 6,788,333 B1	09-07-2004	Uyttendaele, et al.	
		US- 6,754,614 B1	06-22-2004	Barton & Beckstead	
		US- 6,621,516 B1	09-16-2003	Wasson, et al.	
		US- 6,611,282 B1	08-26-2003	Trubko, et al.	
		US- 6,649,103 B1	09-10-2002	Charles	
		US- 6,424,377 B1	07-23-2002	Driscoll Jr., et al.	
		US- 6,392,687 B1	05-21-2002	Driscoll Jr., et al.	
		US- 6,388,820 B1	05-14-2002	Wallerstein, et al.	
		US- 6,373,642 B1	04-16-2002	Wallerstein, et al.	
		US- 6,369,818 B1	04-09-2002	Hoffman, et al.	
		US- 6,356,397 B1	03-12-2002	Nalwa	
		US- 6,333,826 B1	12-25-2001	Charles	
		US- 6,226,035 B1	05-01-2001	Korein, et al.	
		US- 6,222,682 B1	04-24-2001	Hoogland, et al.	
		US- 6,195,204 B1	02-27-2001	Nalwa	
		US- 6,130,783	10-10-2000	Yagi, et al.	
		US- 6,118,474	09-12-2000	Nayar	
		US- 6,028,719	02-22-2000	Beckstead	

## FOREIGN PATENT DOCUMENTS

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Examiner Signature	Date Considered
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Sheet	2	of	2
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